



The Possibilities and Results of Magnetometer Survey in Small-Sized Fortifications of the High Middle Ages. A Case Study on Research into Manorial Residences in the 14th to 15th Century in East Bohemia

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ABSTRACT

The results of magnetometer measurements carried out in small-sized fortifications of the High Middle Ages are presented. In most cases these fortifications were partly or completely abandoned sites. At all sites, structures of anthropogenic origin were discovered. Thanks to the survey various components of residences were identified: internal buildings, fortifications, moats, ramparts. The survey method chosen proved to be suitable for detecting most parts of the 14th to 15th century residences of the petty nobility, particularly in regions with prevailing earthen and wooden architecture. Archaeological structures were detected by way of the survey measurements even at seemingly completely destroyed sites. However, the results of such a magnetometer survey need to be supplemented by other methods of geophysical and archaeological survey.

1. Introduction

High medieval fortified manorial residences located in contexts with built-up areas of villages used to be inseparable components of the medieval cultural landscape. However, most of these fortifications gradually vanished or completely disappeared. But the recent use of non-destructive archaeological methods has made a significant contribution to our knowledge about these fortifications. As yet unknown sites can now be identified with their help (digital terrain models, cropmarks) and in the case of the use of geophysical measurements, current knowledge about the nature of a particular residence can be expanded. This study deals with the possibilities of applying magnetometer measurements to the lowest level of medieval fortifications – the rural residences of the petty nobility (fortified manor houses) of the 14th to 15th century – where only scarce surface remains, or even none at all, have survived.

Although geophysical methods are already well established among the various basic forms of non-destructive archaeological research, their application to the site type mentioned above is fairly uncommon in the context of Central Europe. More specifically, the use of geoelectric resistivity measurements and ground penetrating radar measurements (GPR) may indicate the presence of masonry structures. Geoelectric resistivity measurements over the entire area of a site have been conducted for example in the case of the fortified manor houses at Čimice (Bárta, 1983) and Mastnice in central Bohemia (Dohnal *et al.*, 2000; Krivánek, 1999, p.19) and at Rataje (Baierl *et al.*, 2013, p.10) and Tichá in South Bohemia (Durdík *et al.*, 2013). The GPR measurement method has been applied in the case of the manor house at Dolný Poltár in Slovakia (Tirpák, Fottová, 2008) and the so-called Upper fortress at Kestřany in South Bohemia (Dejmal *et al.*, 2013). Stone structures were detected in all these cases.

In contrast, the use of a magnetometer survey remains underappreciated. This method has been applied in the

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fortified manor house at Obrubce in Bohemia (Křivánek, 2004, p.178), Kersko (Křivánek, 2008) and Neumětely (Křivánek, 2015). Other fortifications have recently been investigated in South Moravia (Dresler, Tencer, 2016; Pelikán, 2017; Vágner *et al.*, 2018; Vágner, 2021, pp.136–138) and one in Lower Austria (Filzwieser, 2018, pp.130–136). Several measurements have been applied in Poland (Bis *et al.*, 2019, p.30; 2020; Kittel *et al.*, 2017, Wroniecki *et al.*, 2017). Despite the above examples, geophysical measurements conducted at such site types are still rare. Moreover, the above sites represent residences of a varied nature in terms of structure and chronology.

The aim of our research was to carry out a targeted magnetometer survey within several abandoned medieval fortifications in a specific region that would be linked by common attributes, and, in so doing, test the use of this method in various excavation situations. The reasons for the application of a magnetometer survey are the positive results that this method can yield when attempting to identify anthropogenic activity (Křivánek, 2004; Milo, 2014).

The main questions asked during the survey are the following:

- to establish the potential of a magnetometer survey in small-sized medieval fortifications,
- to try to identify fortification elements and delimit a residence's grounds (depending on the size and limitations of the field measurements),
- to observe which types of structures could be surveyed by magnetometer,
- to observe the influence of the current state of a site on the measurement results,

- to be able to verify a newly-identified site.

The investigated area was central north-eastern Bohemia, which represents a region for which the occurrence of numerous small-sized residences of the petty nobility was typical during the High Middle Ages. In this landscape, small-sized fortifications (fortified manor houses) located close to village centres were typical types of manorial residences.

2. Materials and methods

Measurements were performed at all available sites in the selected area (Figure 1, Table 1). Sites without visible terrain remains were identified on the basis of observations of cropmarks and research into archival maps. A part of them were localised and recognised for the very first time. The locations were in different habitats (field, meadow, forest, garden) and with various degrees of preservation (terrain remains, without surface remains). The selected sites are only little known: with no archaeological excavation having been conducted at any of them.

The lifespan of most residences can be deduced from a few or rare written records pertaining to their owners and possibly specified on the basis of discovered pottery fragments. All the residences were used during the 14th and 15th centuries. The demise of some 50% of the manor houses can be placed to the close of the 15th century. As late as the beginning of the 16th century, the existence of six residences was still documented; however, they ceased to exist shortly

Table 1. Overview of investigated residences, and their characteristics.

	District	Indicative lifespan	Terrain remains	Surface	Approximate extent of on-site measurements	Subsoil
Babice	Hradec Králové	14 th –15 th c.	yes	meadow	100 %	Floodplain
Bělušice	Jičín	2 nd half of 14 th –15 th c.	yes	forest	40 %	Sandstone
Bříšťany	Jičín	14 th –early 16 th c.	no	meadow	75 %	Floodplain
Dobeš	Jičín	14 th –1 st half of 15 th c.	yes	meadow	40 %	Mudstone
Dohalice	Hradec Králové	14 th –17 th c.	yes	garden	30%	Loess
Habřina	Hradec Králové	14 th –1 st half of 15 th c.	yes	garden	75 %	Loess
Kalthaus	Hradec Králové	2 nd half of 14 th –early 16 th c.	yes	forest	50 %	Mudstone
Kosice	Hradec Králové	14 th –early 16 th c.	no	field	85 %	Floodplain
Mlazovice	Jičín	14 th c. –1424	yes	meadow	35 %	Loess
Nedabylice	Pardubice	14 th –1 st half of 15 th c.	no	field	90 %	Floodplain
Nechanice	Hradec Králové	14 th –16 th c.	yes	meadow	25 %	Floodplain
Přestavlky	Hradec Králové	14 th –15 th c.	yes	forest	50%	Floodplain
Radostov	Hradec Králové	14 th –early 16 th c.	yes	field	100%	Floodplain
Rakov	Jičín	14 th –early 16 th c.	no	field	100 %	Loess
Třebovětice	Jičín	14 th –17 th c.	no	garden	50%	Floodplain
Třesice	Hradec Králové	14 th –16 th c.	no	meadow	80 %	Floodplain
Vysoká	Jičín	14 th –15 th c.	yes	forest	50%	Mudstone

Figure 1. Locations of the sites within Bohemia. 1) Babice, 2) Bělušice, 3) Bříšťany, 4) Dobeš, 5) Habřina, 6) Kalthaus, 7) Kosice, 8) Mlázovice, 9) Nedabylice, 10) Nechanice, 11) Přestavlky, 12) Radostov, 13) Rakov, 14) Třebovětice, 15) Třesice, 16) Vysoká.

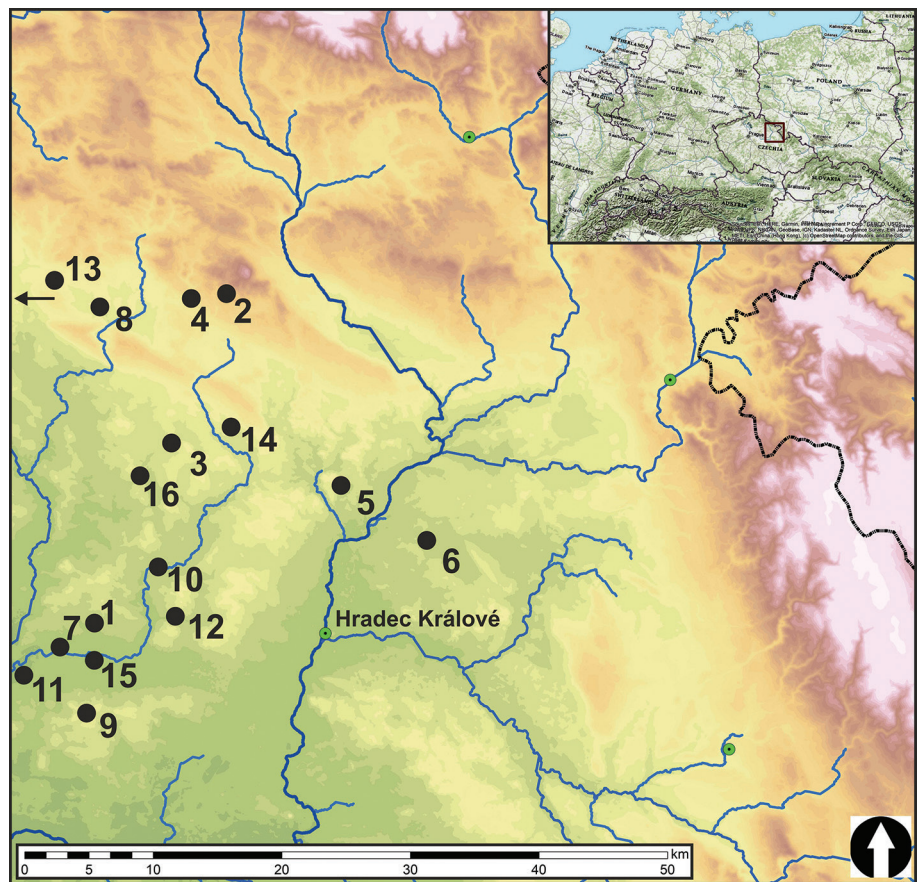
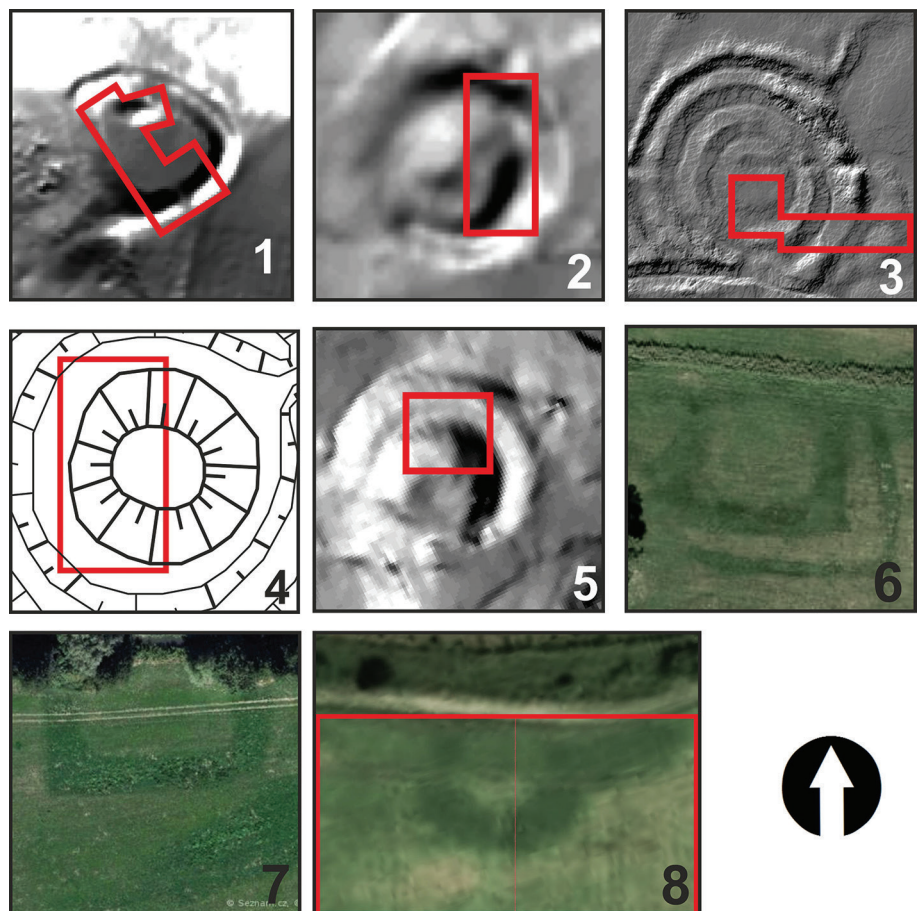


Figure 2. The extent of measurements on sites with preserved terrain remains or cropmarks. The area, which could be surveyed, is highlighted in red. Different scales have been used. 1) Bělušice, 2) Dobeš, 3) Nechanice, 4) Kalthaus, 5) Mlázovice, 6) Třesice, 7) Kosice, 8) Nedabylice.



afterwards. The longest surviving one was probably the fortified manor house at Nechanice, where some written sources allow us to believe that the beginnings of this site may date back to the late 13th century.¹ The precise date and circumstances of a fortification's demise are only known for the manor house at Mlázovice, which was burnt down by soldiers led by Jan Žižka in the spring of 1424 (Čornej, 2019, p.547).

Prospection at relevant sites took place under favourable vegetation conditions in 2021. A Föerster Ferex 4.032 fluxgate magnetometer was used. It was our intention to survey the entire area of the fortifications, which was only partly possible at those sites located in fields and meadows. In the case of residences located in gardens, the situation was further complicated by modern period disturbances (fences, houses). In forested environments with thick vegetation, fortifications could not be completely surveyed to their full extent (Figure 2). The measurements were undertaken in a configuration consisting of four probes (Ferex Con 650), whereas in the case of forested areas only one probe was used to allow for easier movement around the site. The density of the measured points was set in the range of 0.5×0.25 m. The sensing sensitivity was set at 10000 nT which corresponds to the maximum sensitivity available for the measuring unit. The calibration of the probes was done on site, against the local bedrock. The adjustment and export of data were made in Ferex Dataload 3.4.0.1., MagroLight 1.0 and Surfer 21.1.158 software. The subsequent projection onto basic maps was done in the ArcGIS application. The measurement

results were recorded in individual magnetograms. The projection range in nT units is stated for each magnetogram.

3. Results

It was possible to identify anomalies related to human activity at each site. These structures can be divided into the categories mentioned below. The grounds of every fortification are divided into the core where we monitored the presence of features. We presumed the presence of the main perimeter fortification to stretch along the core's perimeter which delimited the central part. The residence's other parts would normally include a moat and a rampart enclosure on the outer side of the moat (Table 2).

3.1 Internal fortifications

Structures interpreted as the remains of perimeter fortifications were observed at eight sites: Babice, Bělušice, Bříšťany, Dobeš, Nedabylice, Nechanice, Rakov and Třesice

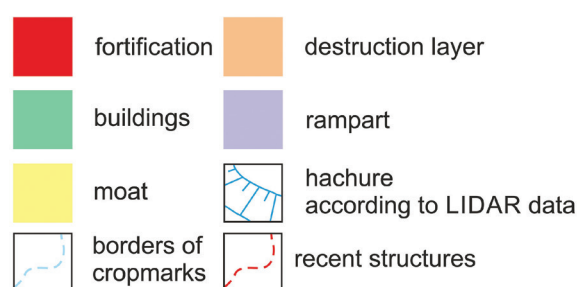


Figure 3. Unified legend for the interpretation of structures recorded on magnetograms.

¹ Basic historical information on the individual sites comes from books by A. Sedláček (1883; 1887).

Table 2. Overview of structures detected by magnetometer survey.

Findings of magnetometry survey						
	Buildings	Inner fortification	Moat	Rampart	Destruction layer	Recent structures
Babice	yes	yes	no	yes	no	no
Bělušice	yes	yes	no	no	no	no
Bříšťany	yes	yes	no	no	no	yes
Dobeš	no	yes	no	no	no	yes
Dohalice	no	no	no	no	no	yes
Habřina	no	no	no	no	no	yes
Kalthaus	yes	no	no	no	no	no
Kosice	yes	no	yes	no	no	yes
Mlázovice	no	no	no	no	yes	no
Nedabylice	no	yes	yes	no	no	yes
Nechanice	no	yes	no	yes	yes	no
Přestavlky	no	no	no	no	no	yes
Radostov	yes	yes	yes	no	no	no
Rakov	yes	yes	no	no	no	yes
Třebovětice	no	no	no	no	no	yes
Třesice	yes	yes	no	no	no	yes
Vysoká	no	no	no	no	yes	yes

Figure 4. Fortified manor house at Babice; the magnetogram is on the left, its interpretation is on the right.

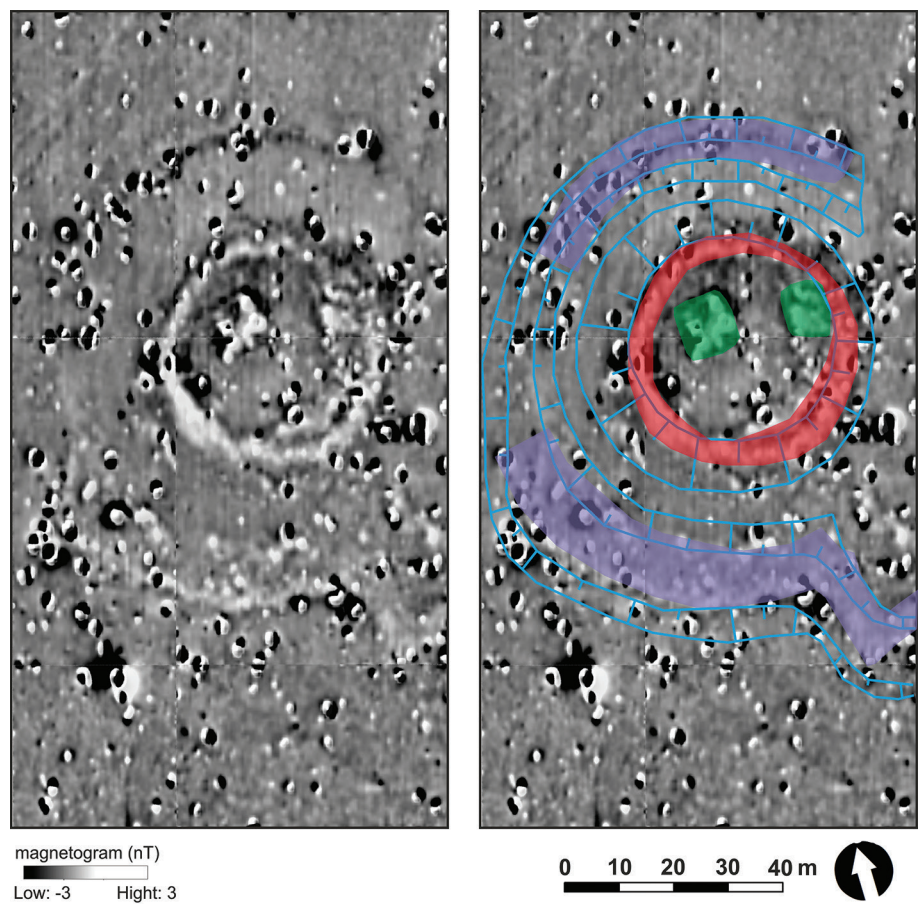
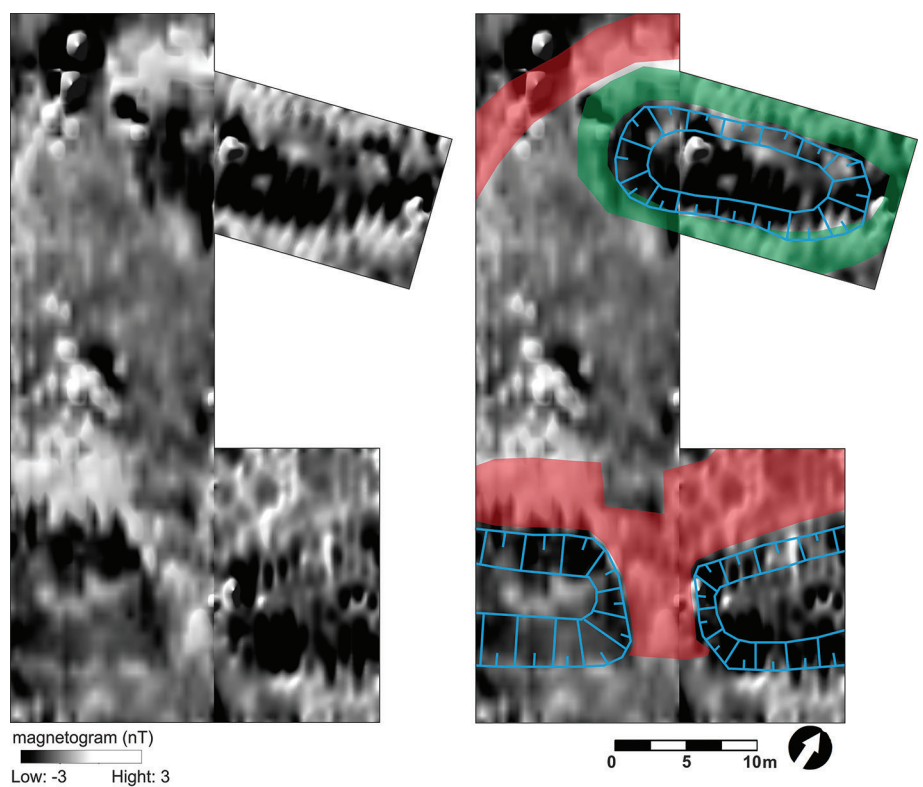


Figure 5. Fortified manor house at Bělušice; the magnetogram is on the left, its interpretation is on the right.



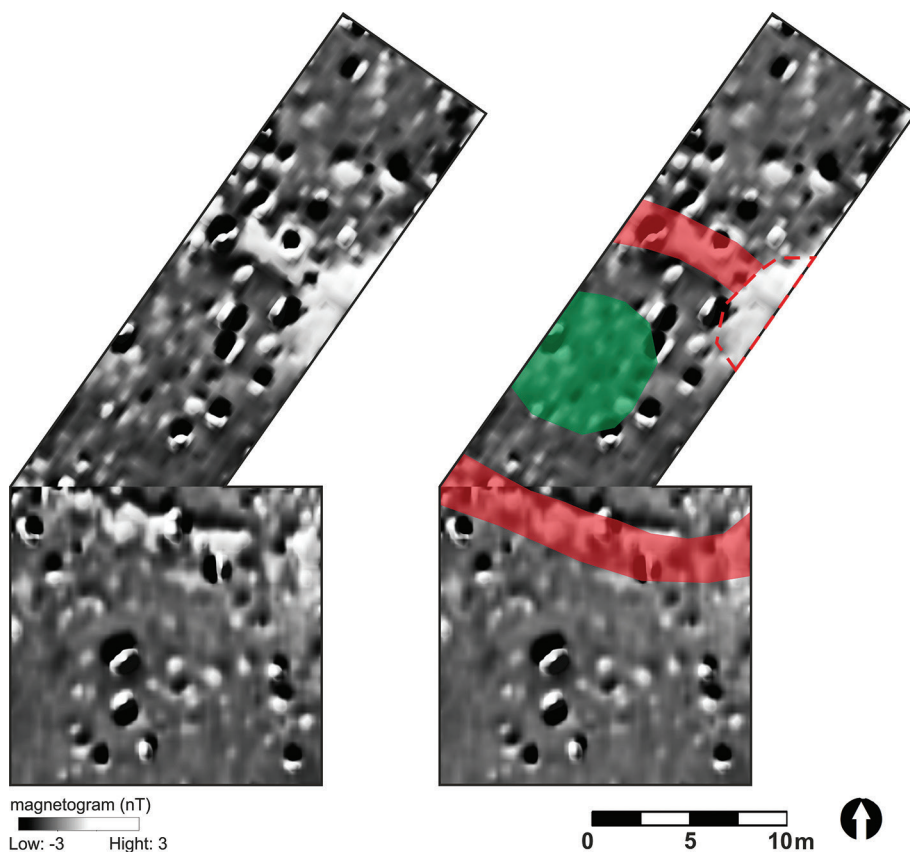


Figure 6. Fortified manor house at Bříšťany; the magnetogram is on the left, its interpretation is on the right.

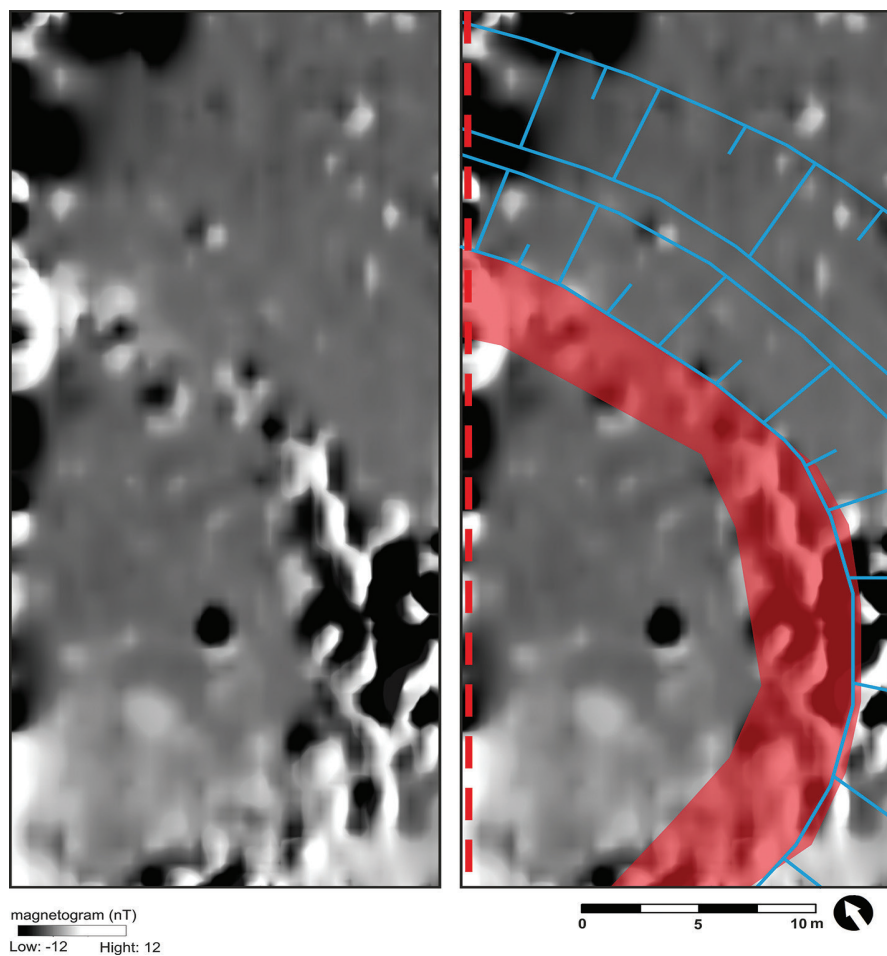


Figure 7. Fortified manor house at Dobeš; the magnetogram is on the left, its interpretation is on the right.

(Figures 4, 5, 6, 7, 11, 12, 13 and 14). These “structures” manifested themselves as strong positive signals at all sites, whereas maximum values were reached in the case of the manor houses at Dobeš and Nechanice. The defensive walls which enclosed the cores of the manor houses at Babice and Dobeš had a regular, circular layout. In contrast to this, the residences at Nedabylice and Třesice had a square layout. An irregular oval form was observed in the manor houses at Bělušice, Bříšťany, and Rakov. The fortified manor house at Nechanice was probably enclosed by a pointed, polygonal defensive wall. The course of the fortifications around the manor house at Bělušice was also observed in the area of the entrance, where it protruded towards the moat. This situation could possibly be indicative of the presence of a gate. No perimeter fortification was noticed in the manor house at Kalthaus – only a separate building used to stand on the artificial motte.

3.2 Internal buildings

Features located within the grounds could be interpreted at the sites of Babice, Bělušice, Bříšťany, Kalthaus, Kosice, Nechanice, Rakov and Třesice (Figures 4, 5, 6, 8, 9, 12, 13 and 14). Such structures usually showed as positive values. The central building of the manor house at Třesice took up the whole area of the surveyed core and several buildings along the core's perimeter were documented in the fortified manor houses at Babice and Rakov. A complete feature located next to the

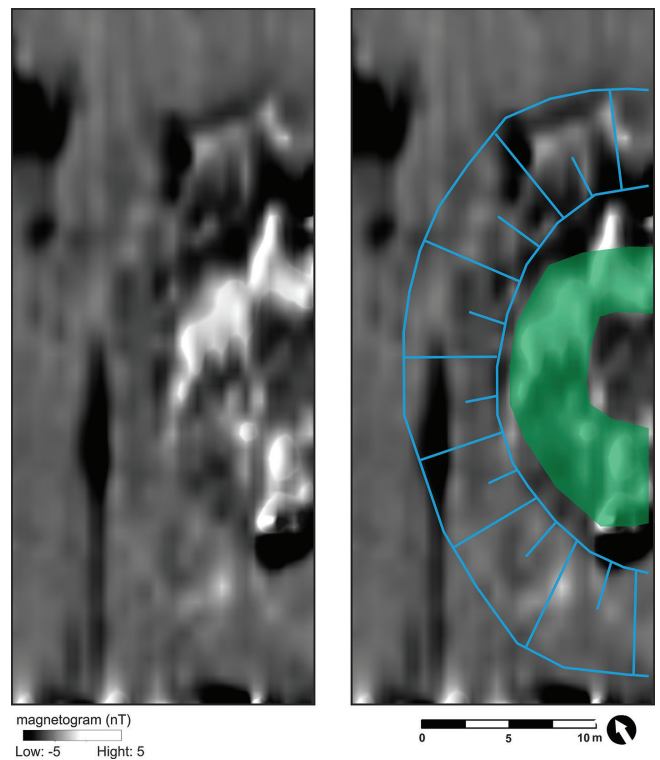


Figure 8. Fortified manor house at Kalthaus; the magnetogram is on the left, its interpretation is on the right.

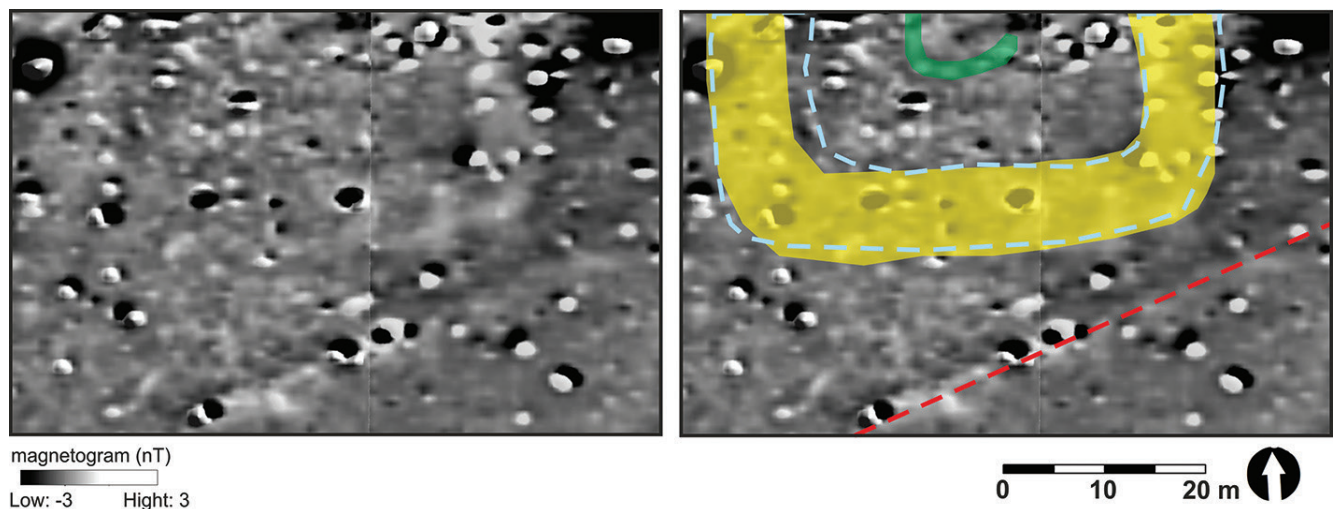


Figure 9. Fortified manor house at Kosice; the magnetogram is on the left, its interpretation is on the right.

core's perimeter which had the form of a terrain depression was documented in the manor house at Bělušice. Complete ground plans of such features were not surveyed at other sites. A central building probably used to stand in the fortified manor houses at Kosice and Kalthaus. In the case of the manor house at Nechanice, this was probably one of the buildings located next to the core's perimeter.

3.3 Moat

Although the presence of a moated enclosure is something to be expected at all sites, it is only in the case of the manor

houses at Kosice and Nedabylice that it could be identified with certainty (Figures 9 and 14). The moat itself could not be discerned, although it was possible to locate it with certainty thanks to well-preserved field remains, or possibly based on cropmarks in aerial photographs. The moat can be rather indirectly defined as the space between the internal perimeter fortification and the inner side of the rampart body. At some sites, the moat could be identified thanks to concentrations of destruction layers (see below). At Kosice, the moat manifested itself as weak positive magnetic anomalies. At Nedabylice, it was visible as a positive line next to the moat's outer edge.

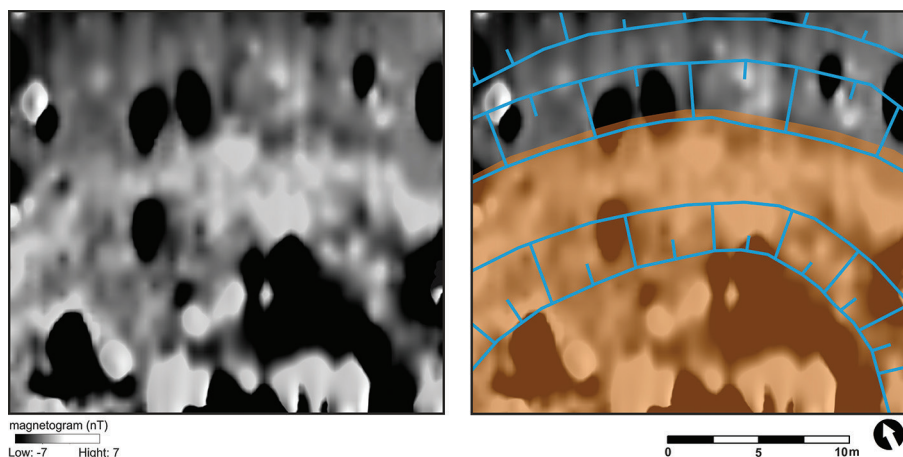


Figure 10. Fortified manor house at Mlázovice; the magnetogram is on the left, its interpretation is on the right.

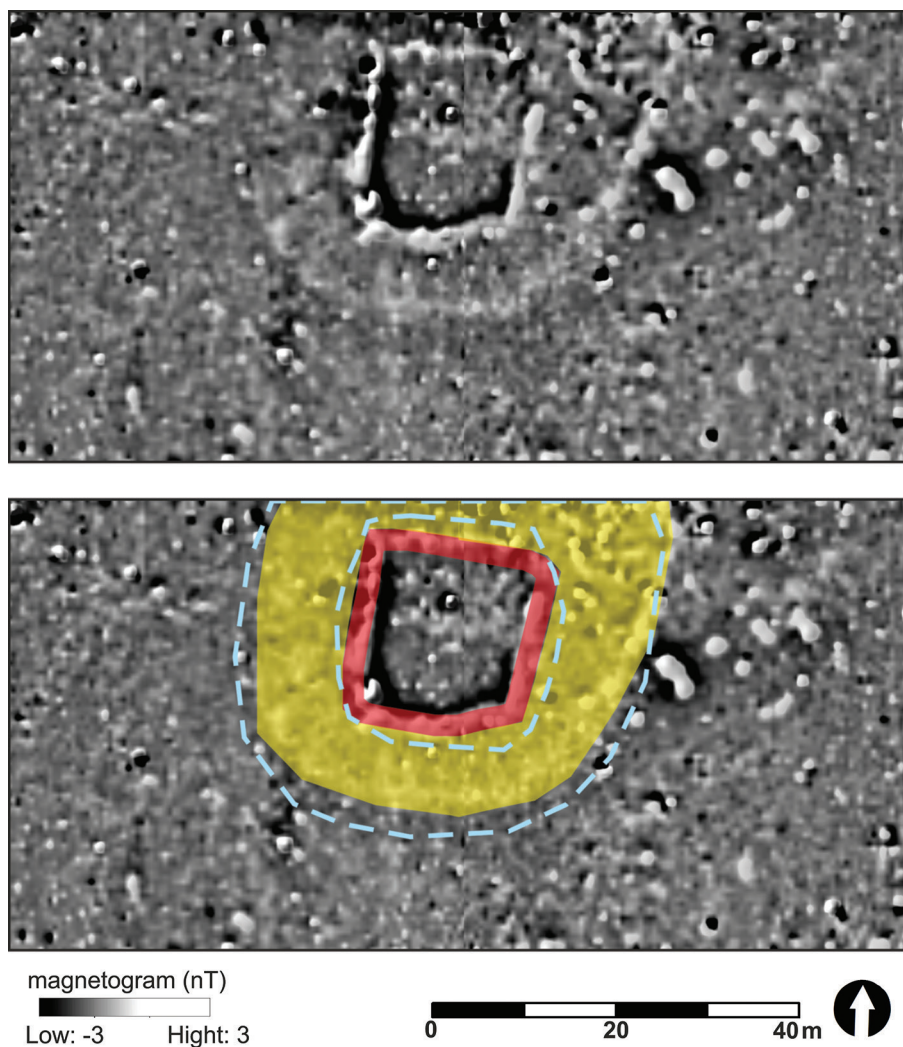


Figure 11. Fortified manor house at Nedabylice; the magnetogram is on the left, its interpretation is on the right.

3.4 Rampart body

The rampart body was identified at two sites: Babice and Nechanice (Figures 4 and 12). In both cases, the outer and inner feet of the ramparts manifested themselves as magnetic anomalies. At Nechanice, these consisted of predominantly positive values; at Babice, they ranged from positive to negative values.

3.5 Destruction layer

Destruction layers are usually regarded as anomalies with highly positive signals which form continuous surfaces within the grounds of fortified manor houses. They are distinctly present in the manor houses at Mlázovice and Nechanice (Figures 10 and 12). In the case of the Mlázovice

Figure 12. Fortified manor house at Nechanice; the magnetogram is on the left, its interpretation is on the right.

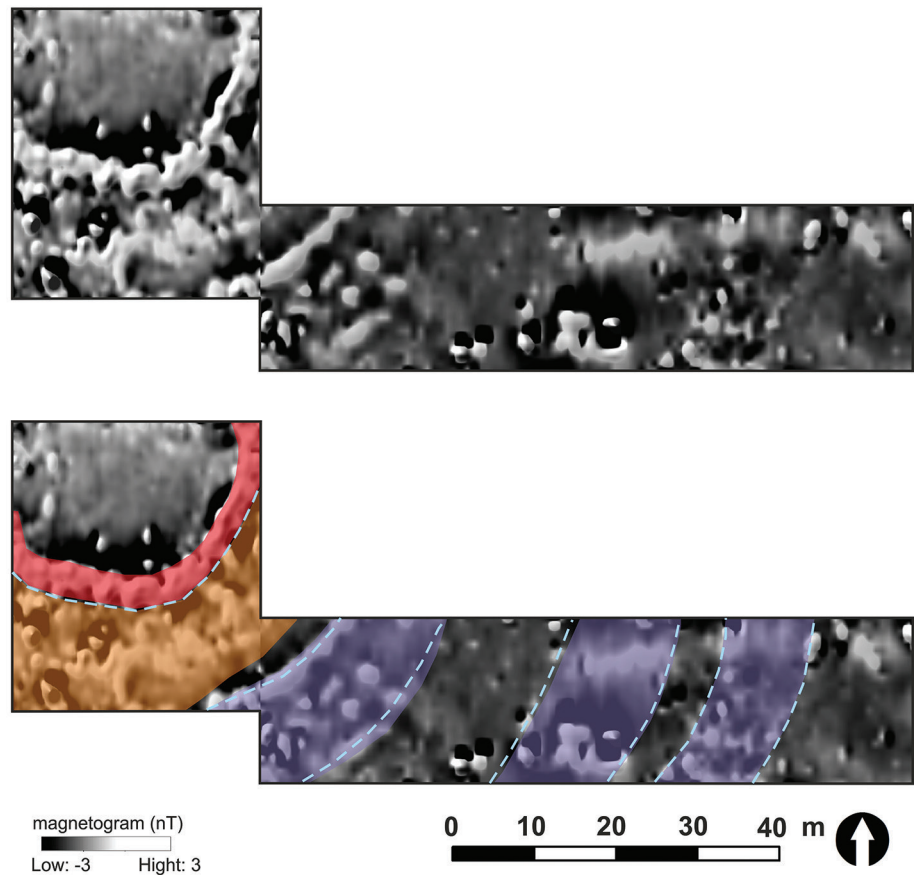
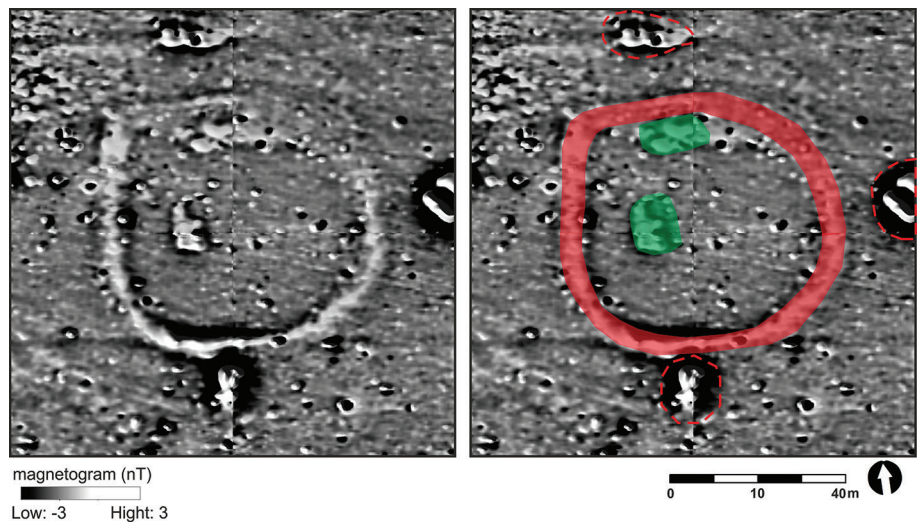


Figure 13. Fortified manor house at Rakov; the magnetogram is on the left, its interpretation is on the right.



manor house, such anomalies cover the surface of the core, the inner side of the moat, and its bottom, but they do not continue on the outer side of the moat. According to our opinion, these are phenomena related to the residence's destruction which were associated with the effects of fire when wooden structures burnt and daub plaster was fired. The debris then slid down from the manor house core to the area of the moat and accumulated at its bottom and next to the moat's inner side. This could explain the absence of positive signals on the outer side of the moat where debris from the

residence's core did not end up. According to the testimony of written sources, the manor house at Mlázovice was destroyed by a military intervention. Fragments of fired daub were also recovered from there during surface prospecting. In the manor house at Nechanice, positive anomalies cover the bottom of the inner moat, they do not occur in the other moats. This situation can again be interpreted as an accumulation of destruction components from the manor house core. The interpretation of the situation in the fortified manor house at Habřina remains complicated. Strong

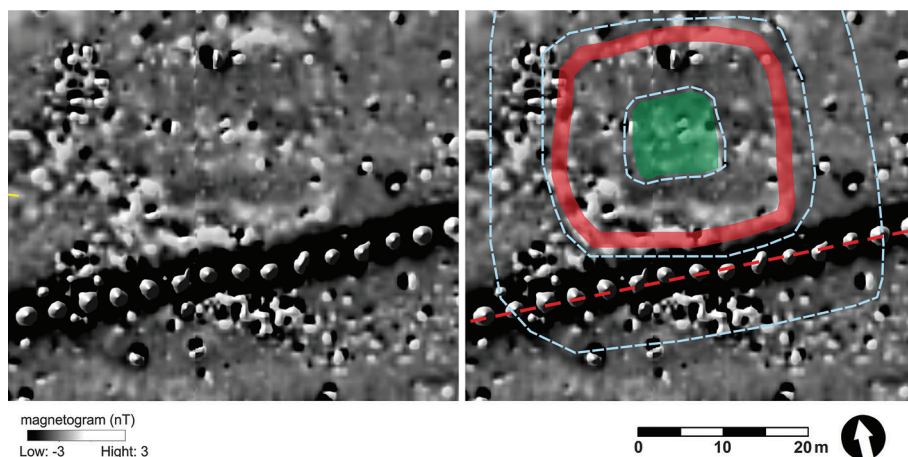


Figure 14. Fortified manor house at Třesice; the magnetogram is on the left, its interpretation is on the right.

positive anomalies there cover the slopes of the motte, while the core itself seems not to contain them. It is impossible to prove without excavation whether this is a manifestation of burnt-down internal structures of the motte. Fired daub can be found there as well.

3.6 Disturbing modern and recent components

Bipolar anomalies covering the surface of most surveyed situations can be regarded as disturbing components. The course of a recent ditch was documented next to the fortified manor house at Třesice. Anomalies south and east of the course of the fortification at Rakov can also be regarded as disturbing and un contemporaneous with the existence of the noble residence. They significantly differed from the remaining anomalies associated with the fortified manor house in their intensity. The strong positive anomaly located next to the eastern edge of the northern course of the fortification of the manor house at Bříšťany is also a manifestation of a recent metal fence enclosing a nearby farmstead.

4. Discussion of results

As already stated in the introduction, the use of magnetometer measurements in small-sized fortifications of the High Middle Ages is not very common. The weakness of this work is the use of only one of the geophysical methods – magnetometry. Important results and verification can be obtained by using other methods: geoelectric resistivity measurement and the ground penetrating radar measurement (Křivánek, 2008; 2015 and Pelikán, 2017). Equally important is verification by archaeological excavation. Research in other localities, where the above methods have been used, can be used to compare our results. An example is the Rozprza motte-and-bailey residence in Central Poland (Kittel *et al.*, 2017) or the locality of Żelechów in Mazovia (Bis *et al.*, 2020). Here it was possible to observe fortifications and internal features on the magnetogram. The results were verified by archaeological excavations. A combination of different

geophysical methods was also used in the research of the fortified manor house Krzczonów in Lesser Poland, where magnetometry also identified a number of positive results (Wroniecki *et al.*, 2017). Comparisons of results between geophysical methods and archaeological excavations was also enabled by surveys of early medieval fortifications in Moravia and Poland (Krasnodębski *et al.*, 2018; Milo, 2019 and Milo *et al.*, 2020). In those cases, settlement features, courses of fortification systems and evidence of the effects of fire could be identified.

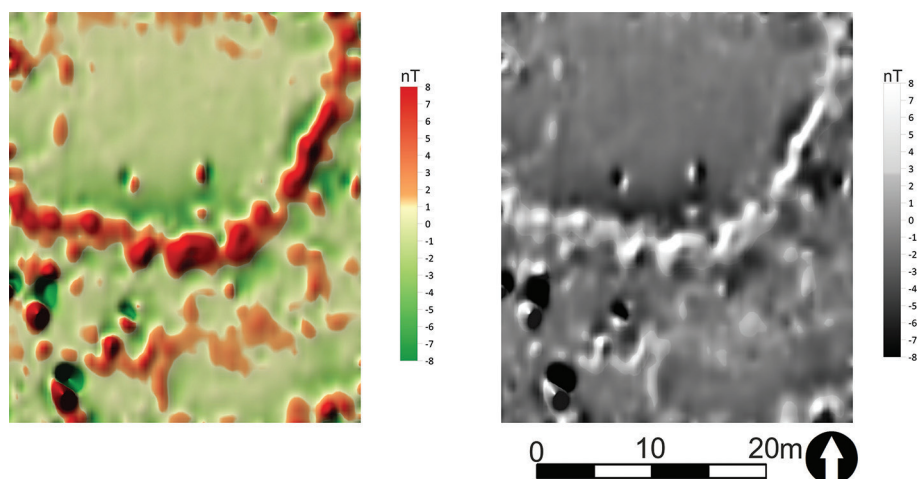
One of the reasons for the inadequate attention that has been paid to small-sized medieval fortifications so far could be the assumption that archaeologically-detectable structures were completely destroyed during recent interventions (levelling out or removal of soil from artificial hills). In spite of such thoughts, the surveys also provided certain proven information about sites which had been completely dismantled and levelled out. It turned out that this kind of measurement is suitable for the investigation of settlements for which we lack any other information concerning their internal structure, extent or the manner of their demise.

Anthropogenic structures were detected at all sites which projected themselves into the final magnetogram. In some cases, it was possible to delimit the grounds of residences and to identify internal buildings. The individual sites are linked by common features: their existence being predominantly in the 14th and the first half of the 15th century, the builder (owner) being one of the local petty nobilities, and the fortifications being part of rural residences.

It can be judged from the results that the main construction element used at all these sites were wooden structures. We did not detect traces of masonry structures at any of the sites. Despite a magnetometer survey being not very efficient when trying to identify masonry structures, it is quite unlikely that such structures would go undetected in all cases.

No archaeological excavation took place at any of the sites which would confirm the results obtained through magnetometer measurements. However, our measurements can be compared with investigations of similar sites elsewhere in Central Europe. In these cases, it was possible

Figure 15. Comparison of different forms of magnetogram outputs. The fortified manor house at Nechanice. To be compared with the Figure 12.



to identify the described structures with features unearthed during archaeological excavations. For example, a wooden palisade wall was documented by the excavation of a motte at Belcz Mały in Silesia (Biermann *et al.*, 2011). Internal buildings, *i.e.*, a wooden central building or several wooden buildings, were identified by excavations of mottes at Ervěnice in Bohemia (Nechvátal, 1965) and Koválov in Moravia (Unger, 1994).

Strongly positive values at certain sites could be indicative of the fact that they had been affected by fire. In the case of Dobeš and Nechanice, these are perimeter walls delimiting the residence's internal grounds. In the manor houses at Habřina, Mlázovice and Nechanice again, we probably managed to identify destruction layers consisting of burnt and charred building structures. The central building in the manor house at Kalthaus, from which finds of burnt daub are known, was probably also exposed to fire. In the case of localities affected by fire, the interpretation of the measured data and the style of the magnetogram are also important. The colour scale may show an alternative representation of the situation on a magnetogram (Figure 15).

Measurement results were influenced by the current state of the surface. Sites in fields and meadows are more contaminated with recent objects. In the case of localities with terrain relics, the position of the magnetometer probes to the measured surface affects the measurement result. The position of the probes and their influence on the measurement is visible in the case of the Bělušice site (Figure 5).

Surprisingly, the existence of moated enclosures did not manifest itself. It seems not to matter whether the moat is currently completely defunct or whether it is still apparent as a terrain depression. Rampart bodies which could be expected in this type of fortification only manifested themselves in a limited number of cases. Sites damaged by agricultural activity could have been completely destroyed, even beneath their base. The magnetically positive anomalies lining the outer and inner feet of the three ramparts enclosing the fortified manor house at Nechanice could be indicative of the presence of reinforcing wooden structures.

5. Conclusion

The magnetometer surveys that were conducted at various sites have shown that this form of geophysical prospecting was useful for obtaining a deeper knowledge of small-sized fortified residences of the High Middle Ages. It was possible to identify sites whose localisation has usually only been based on archival maps or cropmarks. It was also possible to recognise basic components of residences within fortified grounds: internal buildings, walls, ramparts and moated enclosures, and in exceptional cases, also destruction layers. It has turned out that the chosen method was beneficial for obtaining basic knowledge about the investigated site. The results yielded from the magnetometer measurements must be accompanied and complemented by the application of geoelectrical resistivity surveys and radar measurements which are better able to recognise other types of structures, due to their nature. With regard to the fact that most residences of the 14th and 15th century's petty nobility in the northeast of Bohemia were still built of wood and clay, as proven by our research, magnetometry can be regarded as a suitable survey method. However, only classical archaeological excavation is able to provide an in-depth understanding of the residences in question. Furthermore, geophysical surveys are still suitable for gaining a basic overview of preserved structures in a particular fortification.

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